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RESEARCH PAPER

Bringing Agroforestry Technology to Farmers in the Philippines: Identifying Constraints to the Success of Extension Activities Using Systems Modelling

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Abstract This paper presents a systems modelling approach to evaluating the success of an agroforestry extension program in Leyte, the Philippines. During the program, variables which are intrinsic to farmers' socio-economic and farming systems were found to have influenced the uptake and acceptance of extension advice. Evaluation of the program therefore depended on identifying the variables and their interdependencies and assessing their relative influence on program outputs. For this purpose, a systems approach which encourages breaking systems into component variables, but also acknowledges the context of problems, assisted construction of models. Using both empirical data collected during program activities and input from stakeholders, Bayesian Belief Network software was used to predict critical success factors for four aspects of the overall extension system, namely recruitment, use of written extension materials, farmers' self-efficacy and retention of participating farmers throughout the program. A key predicted constraint to program recruitment is farmers' perception of harvest security and while this variable can be partly addressed through dissemination of information on harvesting legislation, title security cannot. Differing levels of farmers' education result in differences in predicted reading ability, comprehension of extension literature and possible misconstrual of information. The variable most critical to the development of farmers' self-efficacy is extended on-farm technical assistance and support.

Keywords Self-efficacy · Harvest certainty · Land tenure · Bayesian belief networks

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Introduction

This paper describes the use of systems modelling to evaluate an agroforestry extension program which was undertaken over 3 years as one of the activities of the Australian Centre for International Agricultural Research (ACIAR) project ASEM/2003/052, *Improving Financial Returns to Smallholder Tree Farmers in the Philippines*. Systems modelling was chosen because it is well suited to the evaluation of agroforestry extension, whereas statistical analysis is best suited to experimental research, which is difficult to evaluate if interventions involve human interaction (Rossi et al. 2004). Economic approaches may require long-term data collection and the usefulness of structured surveys suffers because the context of responses is often ignored (Pretty et al. 1996).

An evaluation process which includes the viewpoints of stakeholders may also be more appropriate than approaches in which assessments are conducted by external experts using predetermined indicators of success (Cramb and Purcell 2001; Owen 2006). Although the evaluation of development assistance in the past has often neglected the complex processes behind assistance uptake, it is no longer acceptable to disregard them (Henderson and Burn 2004; Henriksen and Barlebo 2007). Hence, systems modelling, which includes breaking problems down into component variables, considering interactions between them, recognising the dangers of narrow model boundaries and the importance of qualitative as well as quantitative data (Sterman 2002), matched the evaluation needs of this program. In particular, systems modelling permitted inclusion of the subjective human-behavioural variables which had been observed throughout the program to affect outputs.

Systems modelling also permits prediction of outputs for alternative input scenarios and for extension programs, this is useful to identify critical success factors or impediments. Identification of variables which are within the capacity of program managers to control, allows input-dependent prediction of upper and lower limits of program success. If qualitative variables are included and stakeholders are involved in assessing their influence, models may be populated with data which reflect stakeholders' 'real life' assessment of situations. This increases the validity and reliability of models when they are used to predict the success of extension programs in similar situations.

The systems modelling presented in this paper used data from an extension program on Leyte Island, the Philippines. The program had been conducted as case studies in four municipalities in which farmers were assisted to grow seedlings in home nurseries and establish plantations of *Swietenia macrophylla* (mahogany). Evidence collected throughout the program and from a final survey indicated that the effectiveness of extension activities was influenced by social, cultural and biophysical issues. Accordingly, a systems approach was used to provide answers to three research questions:

1. What extension activities and information are appropriate to recruit smallholder farmers in Leyte and to develop their self-efficacy so that they are able to continue the establishment of trees without further extension assistance?
2. Will an extension program which offers technical advice and assistance be effective in improving the uptake of timber tree establishment?

3. What are the constraints, opportunities and resource requirements involved in scaling up an extension program as described in research question 2, from the local to a wider level?

The first focus of this paper is the application of systems modelling to four aspects of the overall extension system: contacting and recruiting farmers, the effectiveness of written extension materials, development of farmers' self-efficacy and retention of participating farmers over the course of an extension program. The second focus is an evaluation of the methods adopted for the elicitation of information from stakeholders. A final focus is the usefulness of the models to supply answers to the three research questions.

Research Method

The extension program is reported in Baynes et al. (2008) and a précis is presented below. Between 2005 and early 2008, assistance was offered to farmers in Leyte to grow seedlings in home nurseries and establish trees. The program consisted of recruitment, initial training and extension assistance to farmers in the municipalities of Libagon, Dulag, Leyte Leyte and Bato, the Philippines). Recruitment was made through local government unit (LGU) officials after permission had been granted by the municipal mayor. The program was designed to provide assistance in two formats. For volunteer-farmers in the municipalities of Dulag and Libagon, assistance was provided via a field tour which included an overview of small-scale forestry. The tour was followed by extended assistance to grow seedlings and establish trees, mainly mahogany. For farmers in the municipalities of Leyte Leyte and Bato, extension assistance was restricted to the field tour, collecting seed and setting up a home nursery. Compared to farmers in Bato and Leyte Leyte, farmers in Libagon and Dulag therefore received three extra site visits, where in addition to assistance to set up a home nursery, they were advised how to prepare sites, plant and maintain trees. The rationale underpinning the delivery of two assistance regimes was that if farmers are capable of establishing trees once they are initially competent in growing seedlings, then a hypothetically scaled-up extension program would be more cost-effective if extended assistance is not necessary.

Although extension activities were well received, overall recruitment was low, many farmers did not use the written extension materials and the number of farmers who initially participated, declined throughout the program. Farmers initially displayed little knowledge of nursery and tree-growing. Unexpected problems (e.g. persistent rain and predation of seedlings by chickens and rats) caused severe loss of farmers' confidence where extended assistance was not provided. These problems prompted extension staff to identify and document variables which had influenced the success of the program.

Identification of System Variables

To identify variables which had affected program outputs, data were collected as descriptive statistics (e.g. farmer's attendance at extension activities), trip reports,

Table 1 System variables which were or were not addressed in the extension program

Main extension program activities	Variables which were addressed	Variables which were not addressed
Recruitment	Recruitment approach through LGU officials or advertisements Farmers' understanding of harvest legislation Farmers' perceptions of certainty of harvest	Land use Land availability Security of title Political favouritism Mayoral support LGU employee support
Use of written extension materials	Language in which materials are printed Text length Type of material (poster or pamphlet) Style of graphics	Farmers' reading ability Farmers' comprehension of written materials Farmers' construal of the meaning of written materials
Development of self-efficacy	Competence in performing skills Understanding of underpinning theory Opportunity to ask questions and clarify issues Extended support to reinforce technical training	General education Social confidence
Attrition of participating farmers	Initial offer of assistance Extended support to reinforce technical training	Initial self-efficacy[a] Initial feasibility Unexpected problems Destruction of sites through fire, flood or grazing

[a] Self-efficacy is defined in Appendix A

visual observations, translated conversations with farmers, and opinions supplied by ACIAR extension staff. For each of the main extension activities, the variables were classified as either those which were addressed through program activities or those which were not (Table 1). It became apparent that even though the variables were imprecise and their levels often best expressed as subjective probability distributions, they could be arranged as a causal network in which parent variables influenced subordinate child variables through to program outputs. This prompted the arrangement of the variables as a *causal network* and construction of preliminary models.

Construction of System Models

Choice of a systems modelling approach was complicated by the inclusion of both quantitative and qualitative variables, and the need to predict program outputs for varying levels of inputs. A clear visual display was also required to facilitate easy comprehension of models by stakeholders who were to be asked to validate model structure. Using these criteria, spreadsheets, mathematical models, multi-criteria analysis and decision trees were not considered useful because they are difficult to

explain to stakeholders (Cain 2001). In addition, causal loop diagrams do not represent the logical flow of extension activities unless the program is conducted over an extended timeframe. Neither is the concept of 'stock flow' diagrams (accumulation and changes to quantities in a system) easily aligned to modelling imprecise qualitative influences. However, Bayesian Belief Network (BBN) graphical models are suitable for probabilistic modelling through their ability to model cause and effect within systems.

BBNs consist of nodes (boxes) which represent system variables (each node having two or more classes), links which represent causal relationships and probabilities which quantify the chance that a node will be in a particular state given that its input (or parent) nodes are in particular classes. The graphical component of a BBN is called an *influence diagram* and consists of nodes and links. The mathematical component of a BBN uses Bayes' formula to calculate the probability of the occurrence of an event (a conclusion) conditional on the occurrence of other events, (a premise). Variables which can be identified as causally influencing the outcome of other variables are linked into a network and variables further along the chain are modified by the influence of variables higher up. BBNs therefore show the logical consequences of linking the user's understanding of parts of a system into an integrated whole (Jensen 2001; Cain et al. 2003). They are becoming an increasingly popular modelling tool in environmental management because they allow for the integration of biophysical, economic and social variables (McCann et al. 2006, Uusitalo 2007).

In Netica™ BBN modelling software, links encode the conditional dependencies between variables in probability tables. Probabilities inserted into the tables may be derived from empirical evidence or a personal belief and must be based on defensible evidence and reasoning (O'Hagen 2003). Alternatively, if the evidence is taken from a population which is being modelled, then the frequency distribution implicit in that data may be used as an approximation of the desired probabilities (Norsys 2007). The software also provides a sensitivity analysis capability which calculates *entropy reduction* to identify those parts of a model which most affect output variables.

For model construction, data were sourced from descriptive statistics which had been collected throughout the program and qualitative data derived from interviews, visual observations by ACIAR staff and feedback from local government unit (LGU) officials. Overall, 52 farmers initially expressed interest in the program, with sub-sets of farmers involved in various aspects. This provided estimates of some variables which were likely to be more reliable than farmers' and LGU officials' subjective opinions. However, other variables were qualitative, (e.g. farmers' reading ability) and were not easily estimated. Where necessary, this prompted sourcing of data from stakeholders in order to populate models.

Preliminary models of the four main extension activities were constructed following recommendations for model construction that models should be made as parsimonious as possible—capturing the main factors that link a program to its outcomes—without being so complex that the sensitivity of the output variable to input variables is swamped by intermediate variables and validation becomes difficult (Cain 2001; Donaldson and Gooler 2003; Marcot et al. 2006). It was not

possible to involve stakeholders directly in the identification of variables and the construction of preliminary models. Therefore, after initial development, the preliminary models were initially assessed by an expert group of three Filipino researchers, ready for formal validation by stakeholders at a workshop in Leyte. Definitions of key variables are described in Appendix A.

Validating Model Structure and Populating the Models at a Workshop

A workshop was held in Leyte in July 2008 to validate and populate the models. Fourteen stakeholders participated in the workshop, comprising seven extension program participants who actively farmed their land (farmers) and seven participants who employed farm labour rather than performing the work themselves (non-farmers). All of the non-farmer group had outside employment or held positions in local government.

Validation of the preliminary models was premised on the definition proposed by Cain et al. (2003) that the validity of data elicited from stakeholders is contingent on inducing them to offer their own perspectives and participate in discussion. Because the results of the workshop could be compromised if shyness or reading and writing limitations inhibited participants from responding fully to questions, it was decided to employ a one-to-one ratio of assistants to workshop participants. The task of the assistants was to translate if necessary, recapitulate information or instructions, elicit comments and to record a verbatim reply to each question. Fourteen staff were available to assist with the workshop and the number of participants was also consequently set at 14.

The workshop had two objectives, to validate the structure of the preliminary models and, where necessary, to populate the models. Using a simple BBN model, a Cebuano-speaking facilitator first demonstrated the calculation of conditional probability. Each of the four models was shown to the participants and the meanings and definitions of the variables were explicitly described. Participants were then asked to comment whether they thought that the models and their constituent variables were realistic, and an accurate representation of the influences which affect farmers' motivation and engagement in small-scale forestry. They were also asked whether variables should be added, deleted or re-ordered in the networks. Finally, they were asked to assess the probability of the incidence of each variable.

Participants were asked to indicate on a Likert scale their opinion of the likelihood of each variable taking a particular state and to make a written comment. To ensure that responses were only used when participants had understood the question, whenever participants did not record a comment which matched their response on the Likert scale, their response was treated as invalid. Valid Likert scale responses were averaged and the resulting mean probabilities entered into BBN probability tables. If two or more parent variables influenced a child variable, participants were asked to weight the influence of the variables in *elicited probability tables* using the procedures described by Cain (2001).

It was possible that socio-economic differences between the farmer and non-farmer groups may have caused them to respond to questions differently. Therefore, because the sample size was small, for four variables, a non-parametric

Mann–Whitney rank-sum test was performed for data supplied by both groups to test whether the farmer and non-farmer group had responded differently. The variables were:

1. On non-intensively managed farms, the probability of farmers having land on which to plant trees
2. The likelihood of political favouritism affecting recruitment in municipalities
3. Farmers' ability to read paragraphs, written in their local dialect
4. The probability of farmers having insecure title to their land.

The four variables were chosen because they are examples of variables which were wholly or partly beyond the capacity of the extension program to control and because they are potentially critical impediments to the success of an expanded program.

Workshop Outcomes

Workshop participants validated the structure of three models, i.e. models of the recruitment of farmers to an agroforestry extension program, the effectiveness of extension materials and the development of self-efficacy. They also supplied data with which to populate the models. For a fourth model which describes the attrition of participating farmers throughout a program, participants validated the structure of the model but empirical data which had been collected during the extension program were used to populate probability tables.

For most questions, the assistants were able to record a comment which indicated that participants understood the nature of questions. Overall, only 6.5% of responses were rejected because participants did not supply a valid comment.

For the four variables to which the Mann–Whitney rank-sum test was performed for data supplied by the farmer and non-farmer groups, a test of probability estimates assigned by both groups showed that for each variable, no significant difference was found between the responses obtained from each group ($P \geq 0.05$, two-tailed test). Data from all 14 participants were therefore processed as one dataset.

Result of Workshop Participants' Input for Model 1: 'Recruitment of Farmers to an Agroforestry Extension Program'

In preliminary questions, participants provided a demographic snapshot of a 'typical' farmer in Leyte. The average age of farmers in Leyte was estimated as being over 50, with 35% of them having only elementary education or not having attended school. Approximately 30% of farmers were categorised as being poor tenant farmers with a consequent low level of involvement in community affairs.

Participants suggested that the recruitment of farmers to an extension program should be treated first as the level of contact achieved with farmers at the municipal level (Model 1a, Fig. 1) and second as the recruitment of farmers at a personal level (Model 1b, Fig. 2).

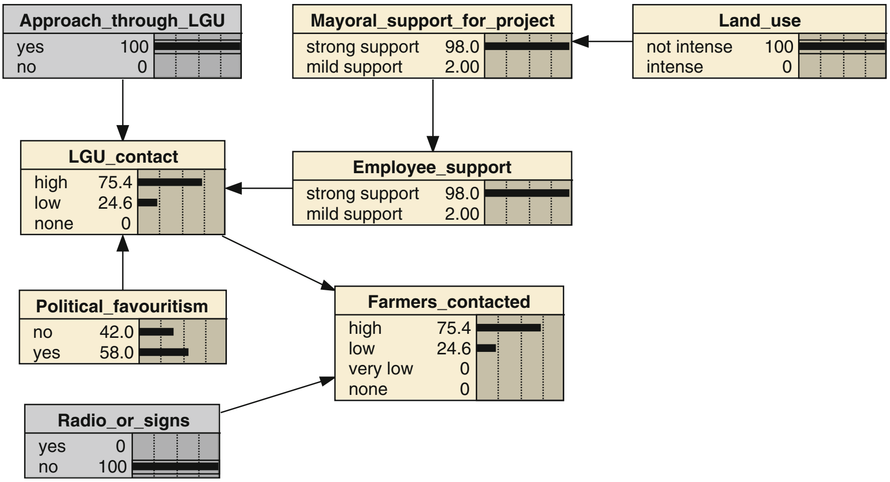

Fig. 1 BBN model of the level of initial contact with farmers achieved through LGU staff or radio and painted signs

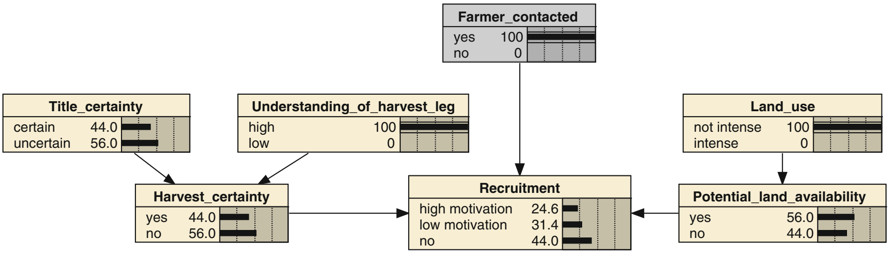

Fig. 2 BBN model of influences which affect the motivation of farmers to be recruited to an agroforestry extension program

Participants accepted that contact with farmers at the municipal level is affected by land-use, mayoral support, employee support and political divisions (Fig. 1). Once farmers have been contacted, however, they considered that recruitment is contingent on land availability and farmers' perceptions of harvest certainty, as described in Fig. 2. Harvest certainty was seen as being influenced by farmers' security of title to their land and their understanding of harvest legislation.

In Fig. 1, the predicted level of support from municipal mayors is strongly influenced by the intensity of land use in the municipality. If typical farms are not intensively cultivated, strong mayoral support is highly probable (i.e. 98%), whereas if land in the municipality is typically intensively harvested, agroforestry or protective tree planting is not a political priority and the probability of strong mayoral support is predicted to be only 38%. This finding mirrors the results of the extension program and indicates that agroforestry programs are much more likely to be supported by elected officials and LGU staff in situations where land is not seen as being profitably used for annual crops.

For land which is not intensively farmed and where no political tensions exist in the community, the predicted probability of achieving a high level of contact with farmers is 96%, compared to 61% where divisions exist. Using empirical data collected during the program, the model was constructed so that the probability of contact with farmers is ‘very low’ if only radio announcements or painted signs are used to contact farmers. Despite detailed planning and execution, recruitment through these media in the municipalities of Libagon and Dulag (signs) and Baybay (radio) had been an almost complete failure. Participants commented that although political favouritism is a normal factor of rural Filipino life they envisaged that the culturally appropriate way to gain access to communities is via elected politicians.

For farms which are not intensively managed, participants rated the probability of land being available to grow small numbers of trees[1] as being 56% compared to 38% for land which is intensively managed. On intensively managed land therefore, participants still saw considerable scope for small-scale tree planting. Several participants commented that farmers would always have a preference for growing annual crops, but that the security of these crops is difficult on plots of land distant from the family home.

The probability of farmers having a high understanding of harvest legislation (25.6%) had been derived from interviews with 39 farmers during the extension program. In addition, at the workshop participants considered that the probability of farmers having security of title was only 56%, this issue being a serious impediment to the development of farms in the Philippines. Using these data, only 11% of farmers are predicted to be certain of harvesting their trees (‘harvest certainty’, Fig. 2). Alternatively, if an extension program provides information sessions so that all farmers have a high understanding of relevant legislation, the predicted probability of harvest certainty rises to 44%. An upper limit to the likelihood of farmers being highly motivated to join an extension program is predicted to be 25% for a scenario in which harvest certainty is raised through an educational program and land use is not intense.

Result of Workshop Participants’ input for Model 2: ‘Effectiveness of Written Extension Materials Which are Used as an Extension Aid’

The purpose of Model 2 is to supply answers to research question 1 by predicting the effectiveness of written extension materials as instructional aids or as ‘stand-alone’ documents. Using the design of extension material which was developed for the program as a guide, the initial model was developed with ‘language’, ‘text length’, ‘document length’, ‘graphics’ and ‘type of material’ as parent variables. Key measures of effectiveness are farmers’ comprehension of written material and the correct construal of meaning.

Participants accepted the structure of Model 2 and provided data which predicts that farmers’ reading ability is affected by both the language in which material is presented and the length of text, either phrases or paragraphs (Fig. 3). Participant assessments of farmers’ reading ability were that reading skills decline with

[1] The number of trees was nominally set as being at least 50.

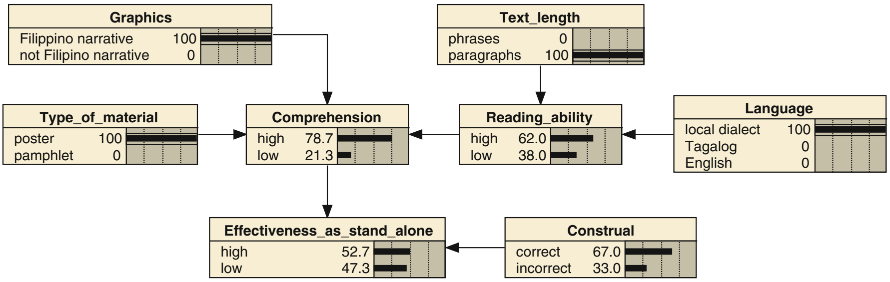

Fig. 3 BBN model of the effectiveness of written extension materials as stand-alone extension aids

Table 2 Predicted probability of farmers being able to read either phrases or paragraphs in their local dialect, Tagalog or English

Language (%)	Text presented as phrases	Text presented as paragraphs
Farmers having 'high' reading ability in their local dialect	97	62
Farmers having 'high' reading ability in Tagalog	84	59
Farmers having 'high' reading ability in English	58	38

increased text length and with departure from the local dialect to the national language (Tagalog) or to English. For extension material presented as phrases, the predicted probability of farmers having a high level of reading competency—in their local dialect (Cebuano or Waray Waray), Tagalog or English—is 97, 84 and 58%, respectively (Table 2), whereas if material is presented as paragraphs, the predicted percentage of farmers having a high level of reading competency declines from 62 to 59 and 38%, respectively. These results preclude use of written material which is written in other than the local dialect.

Participants expressed a strong preference for 'Filipino style' narrative graphics rather than annotated diagrams. Using narrative graphics, and for extension material presented as pamphlets, the predicted probability of farmers having a high comprehension of extension material declines from 92% if farmers' reading ability is high, to 57% if farmers' reading ability is low.

It would have been inappropriate to ask workshop participants about the extent to which farmers may misconstrue the meaning of extension information. However, previous interviews with farmers in which they had been asked to validate written extension materials had indicated that their misconstrual of illustrations concerning pruning and thinning was 17 and 33%, respectively (Baynes et al. 2007). For scenarios where written extension material is presented as pamphlets, written in paragraphs in a local dialect and with narrative graphics, the predicted correct construal of extension material when used in the absence of verbal assistance declines from 62 (where the misconstrual rate is 17%) to 50% (where the misconstrual rate is 33%).

Result of Workshop Participants' Input for Model 3: 'Development of Farmers' Self-Efficacy'

Model 3 addresses the need for farmers to develop self-efficacy (research question 1) and the resource requirements for a scaled-up program (research question 3). Workshop participants accepted that farmers' social confidence during participation in extension activities is affected by their social status and their level of education. Hence, the principles of adult learning, as described by Knowles (1984), may not be applicable to some Filipino farmers because limited education and low social rank may inhibit them in extension situations. Consequently, Model 3 was modified so that farmers' social confidence is modelled as a surrogate of farmers' education (Fig. 4).

In this model, if farmers' social confidence is high, predicted self-efficacy declines with the reduction of inputs from 92% at an optimal state (i.e. individual competence, simple theory, extended questions and extended assistance) to 44% where inputs are in their most negative state (Table 3). Similarly, if farmers' confidence is low, self-efficacy declines from 79 to only 38% (Table 3).

A sensitivity analysis was undertaken of the sensitivity of 'self-efficacy' to variation in 'prac session effectiveness', 'theory session effectiveness' and 'technical reinforcement'. The entropy reduction—the uncertainty of the output variable which is expected to be eliminated if the population value of other variables are known—was 6.0% for 'technical reinforcement', 3.8% for 'practical session effectiveness' and 2.4% for 'theory session effectiveness'. These results indicate

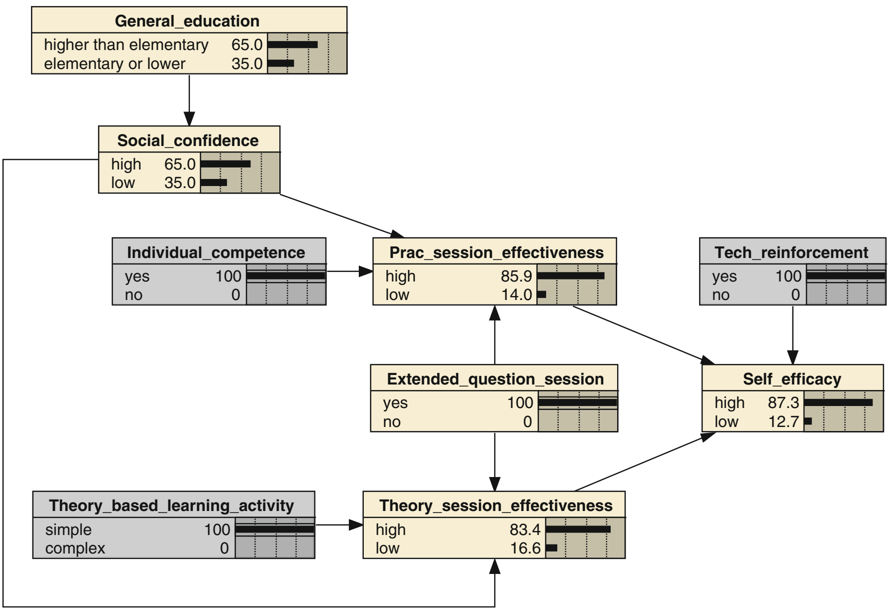

Fig. 4 BBN model of the development of farmers' self-efficacy through training followed by technical reinforcement

Table 3 Predicted probability of farmers achieving self-efficacy through the provision of practical and theory training and technical reinforcement

Technical reinforcement	Practical competence	Type of theory delivery	Questions encouraged	Farmers with high social confidence who achieve high self-efficacy	Farmers with low social confidence who achieve high self-efficacy
Yes	Yes	Simple	Yes	92	79
Yes	Yes	Simple	No	79	73
Yes	Yes	Complex	No	76	71
Yes	No	Complex	No	71	66
No	No	Complex	No	44	38

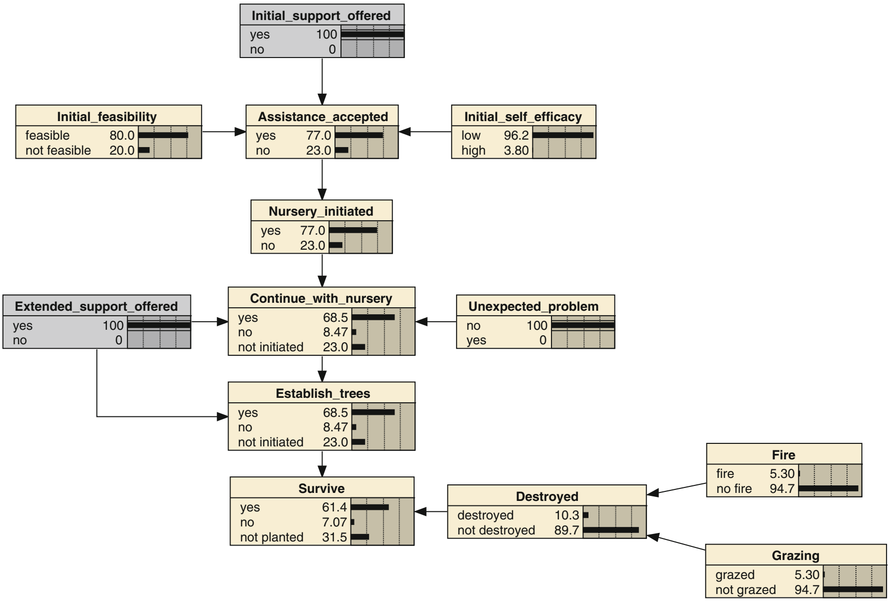

Fig. 5 BBN model of attrition of farmers' participation in an agroforestry extension program

that the reinforcement of technical training which is supplied through extended on-farm assistance is the most critical success factor for the development of self-efficacy.

Result of Workshop Participants' Input for Model 4: 'Attrition of Participating Farmers Throughout the Program'

Using data which had been collected during the extension program, Model 4 describes the attrition of participating farmers throughout a program of this nature (Fig. 5). The main variable within program managers' capacity to control is the provision of extended assistance. The model provides a response to both research question 1 and 2 by predicting the percentage of sites which are planted and for

Table 4 Decline in predicted percentage of farmers participating in an extension program

Scenario	Farmer participation with extended assistance (%)	Farmer participation with initial assistance (%)
Encounter severe nursery problems but persist	68	7
Establish trees	68	4
Site survival after 1 year	61	3

which trees survive, depending on the level of extension assistance. The model shows a decline in participation because: farmers already know how to establish trees; they decide that tree establishment is not feasible; unexpected problems occur; they lose interest over a period of time and planted trees are destroyed by grazing or fire (Fig. 5).

Only 77% of farmers who accept an invitation to an introductory field day are predicted to initially participate in a program and receive training to begin a home nursery. Some farmers are then predicted to lose interest with participation falling to 68% even if no severe problems occur (Table 4).

If expected problems are encountered at the nursery stage, and extended assistance is not provided, the predicted attrition of participating farmers is very severe, only 7% of farmers growing seedlings to the planting-out stage. In addition, if encouragement and extended assistance to plant trees are not provided the predicted establishment rate of sites is reduced to only 4%. Finally, for this scenario, a predicted loss of approximately 10% of sites in the first year reduces the percentage of surviving sites to only 3%. Even if farmers do not encounter unexpected problems, if encouragement and support are not offered, the predicted tree establishment rate is only 36%, a reduction of almost half of participating farmers because they gradually lose interest or are distracted by other activities.

Discussion

One of the principal advantages of a systems approach to extension evaluation is that identification of system variables and assessment of their importance provides a rich picture of the socio-economic context in which extension takes place. However, in systems approaches involving stakeholder input, there is also the potential for participants to accept spurious influences out of a sense of politeness or indifference. It is a Filipino characteristic to try to accommodate other viewpoints and attitudes (Carson 1978; Goldoftas 2006) and culturally sensitive variables may be ignored or glossed over in a workshop situation.

The ability of BBNs to accommodate imprecise estimates of qualitative variables is highly advantageous in extension, which by definition is concerned with subjective human values and attitudes. Unfamiliarity with the concept of probability can limit the extent to which stakeholders can provide probability estimates and a variety of methods have been used to elicit input from them, examples being a consensus-based approach followed by expert group review (Henderson and Burn

2004) and a sample survey (Cain et al. 2003). Henriksen and Barlebo (2007) used stakeholder opinion to populate BBN models of groundwater management, but found that explaining BBNs was demanding and time consuming. For this workshop, ACIAR staff commented that without the individual assistance supplied to every workshop participant, little response may have been elicited from those who were less socially-secure. Personal assistance permitted translation and repetition of questions to individual participants. ACIAR staff commented that this elicited responses which were genuine and considered.

For program managers, the ability to analyse the sensitivity of program outputs to inputs may assist planning and re-direction of resources away from activities which are likely to be less successful. In addition, prediction of limits to program outputs allows appraisal of the fundamental worth of programs. A difficulty with this type of evaluation is that it must be carried out *ex poste* once the variables have been identified and their importance at least tentatively assessed. An *ex ante* evaluation invites model construction based on speculation. For this program, several variables (e.g. farmers' attitudes to fencing or fire control) emerged only late in the program and the importance of a key impediment (title security) only emerged at the final workshop.

Usefulness of the Models to Supply Answers to the Three Research Questions

In providing a response to research question 1, i.e. 'what extension activities and information are appropriate to recruit smallholder farmers in Leyte and to develop their self-efficacy so that they are able to continue the establishment of trees without further extension assistance', modelling showed that nursery-based technical information was particularly valued by farmers and that personal assistance was highly effective in achieving technology transfer. A comparison of the predicted levels of contact with farmers for different levels of land-use intensity and political favouritism indicated that high levels of these variables are not critical impediments to an extension program. Contact with farmers is reduced substantially where political cronyism exists. However, participants' comments—that it is unrealistic to expect an extension program to work in a politics-free environment—indicated that the influence of this variable may be unavoidable.

Participants' insistence that a low level of recruitment will be achieved if title security and harvest legislation issues are not resolved, indicated that these issues are critical impediments for an extension program of this nature. Strengthening land tenure and harvest rights is often described as a prerequisite for increased agroforestry adoption, e.g. in Panama (Fischer and Vasseur 2002), in Haiti (Murray and Bannister 2004) and in Sumatra (Suyanto et al. 2005). The results of this research indicate that in the Philippines, unless land tenure and harvest rights are secure, the adoption of agroforestry is unlikely to be adopted beyond its low existing level. Whereas farmers' lack of knowledge of harvesting legislation can be easily remedied, title security cannot. Unfortunately the complexities of Filipino law preclude a simple remedy for farmers with insecure title. Addressing farmers' awareness of harvesting legislation is therefore a critical success factor for program

recruitment and an opportunity which may be exploited in a scaled-up extension program.

As a further response to research question 1, for the predicted 38% of farmers who have difficulty reading paragraphs written in their local dialect, the usefulness of written extension material is marginal. This is in accord with the findings of Kiptot et al. (2006) in Kenya, that technical information must be simplified to help farmers' understanding of complex principles. In this case, even when graphics are included to bolster comprehension, approximately one farmer in four is predicted to fail to comprehend written materials. The consequences of misconstrual of the intended meaning of extension literature are potentially serious. Farmers' mental model of the world may be likened to an invisible force which guides their actions (Eckert and Bell 2005). For agroforestry extension in Leyte, this modelling indicates that use of written extension materials, if not supported by verbal explanations, is ineffective.

For research question 2, i.e. 'Will an extension program which offers technical advice and assistance be effective in improving the uptake of timber tree establishment?' extension assistance is predicted to be highly effective when delivery is optimised to accommodate farmers with limited education and self-confidence. Self-efficacy is a precursor to adaption and experimentation with technology. Hence, because farmers' innovations are entry points for technology development and adoption (Katanga et al. 2007), variables which affect the development of self-efficacy are key drivers of program success. The finding of this research—that 35% of farmers may be apprehensive in learning situations—is of concern. These farmers are less likely to develop initial self-efficacy and are more dependent on reinforcement of skills and knowledge. Even in situations where farmers achieve initial competence, only extended assistance may enable them to deal with contingencies. Consequently, if unexpected problems occur and extended assistance is not provided, the predicted loss of farmers' participation is predicted to be catastrophic.

It was initially expected that lack of a production to commercialisation (P–C) chain for timber trees may constrain farmers' enthusiasm for extension assistance. A well-identified P–C chain provides crops with a distinct adoption advantage (Kwesiga et al. 2003; Clement et al. 2004), but in this program farmers had previously identified domestic use (to build a house) as a main reason for growing trees. For the development of small-scale forestry in Leyte, the development of a P–C chain may be an opportunity, but farmers did not identify it as a constraint.

As a further response to research question 2, the refusal of approximately one quarter of farmers who attended an introductory extension activity to then participate in an extension program may not be an important indicator of the suitability of program offerings. ACIAR staff commented that some farmers may enquire about a program to see what material benefits it may bring and a proportion of farmers are likely to be unable to come to an arrangement with parents, siblings or landlords which will allow them to participate. An early loss of participation of farmers from a program may not imply that recruitment methods are at fault.

Unfortunately, a predicted loss of approximately 10% of sites planted in the first year is a serious impediment to the further adoption and diffusion of tree

establishment. Negative publicity emanating from the destruction of trees is a serious impediment to lifting the level of tree establishment. Fencing is a prerequisite if there is a risk of trees being grazed and any form of fire control (e.g. liaison with neighbours) is highly advisable.

A response to research question 3 is collectively provided by responses to research questions 1 and 2. For a hypothetically expanded program, a constraint is that contact with farmers is only likely to be achieved through elected officials. However, an opportunity to maximise recruitment is provided if farmers' fears of being unable to harvest trees in the future are addressed by providing information on harvesting legislation. Resource requirements for a hypothetically expanded program are predicated by the limited usefulness of written extension material and farmer's preference for extended personal contact with extension staff. Finally, the negative impact of farmers' reaction to the loss of trees through grazing or natural disasters represents a system variable over which program managers may have little control.

Conclusion

For the evaluation of this extension program, systems modelling has provided insights into the values and socio-economic conditions of farmers which would have been difficult to gain by other means. Use of the BBN modelling approach permitted construction of preliminary influence diagrams in which rearrangement of variables and causal links could be undertaken until a logical model emerged. Without the willing cooperation of workshop participants, validating and populating preliminary models would have been very difficult.

The system variable common to all four models is farmers' education and knowledge, in relation to their understanding of harvest legislation, comprehension and construal of written information, development of self-efficacy and their ability to cope with problems. Systems modelling highlighted the difficulty of targeting the cohort of farmers most in need of extension assistance, namely those with low education and social position. If these farmers are not explicitly targeted in program design, then the program may mainly benefit richer or better educated farmers. Hence, to maximise the effectiveness of a hypothetically expanded program, extended assistance and support are necessary. Fortunately, the high predicted success rate when extended assistance is provided indicates that programs of this nature may present an opportunity to help those farmers most in need.

Appendix A Definitions of Models and Key Model Variables

Model 1a 'Farmers Contacted by an Agroforestry Extension Program'

The model predicts the likelihood of farmers (who are be potentially predisposed to growing trees) being contacted and responding to an invitation to join an extension program which offers assistance to grow trees.

Variable	Definition of each state
LGU contact	'LGU contact' is defined as 'high' in situations where more than 15 farmers (who may potentially be interested in growing trees) per municipality are contacted, invited to be included in program activities and respond to the invitation. 'Low' contact is defined as being contact with less than 15 farmers per municipality.
Farmers contacted	For the definition of this variable, it is assumed that farmers may be interested in information about growing and managing trees for a variety of reasons, e.g. planting, valuing, application of silviculture, curiosity or the material benefits which the program may bring. 'Farmers contacted' is defined as 'high' in situations where more than 15 farmers per municipality are contacted, invited to be included in program activities and respond positively to the invitation. 'Low' contact is defined as being contact with less than 15 farmers and 'very low' contact is defined as being contact with only one or two farmers per municipality.

Model 1b 'Farmers Recruited to an Agroforestry Extension Program'

The model predicts farmers' motivation to join an agroforestry extension program. It is assumed that for farmers to join the program in a fully participative manner, they must have unused land for which there is no alternative use and they must have security of harvest.

Variable	Definition
Potential land availability	'Potential land availability' is defined as being 'yes' or 'no' depending on whether there is sufficient space to grow 50 or more trees, or not, either as a block, rows or as inter-plantings.
Recruitment	'Recruitment' is defined as 'high motivation' in situations where farmers, after being introduced to the program, are motivated to join the program and supply necessary inputs to establish trees. 'Low motivation' is defined as occurring in situations where farmers join the program (often to see what material benefits it will bring) but soon lose enthusiasm and abandon their efforts or establish a minimal number of trees. 'No' recruitment is defined as a decision to not join the program.

Model 2 'Effectiveness of Written Extension Materials as an Extension Aid'

Model 2 predicts the probability of farmers being able to comprehend (as a personal belief) written extension materials. The model also predicts the probability of farmers being able of construe the correct interpretation of written material which is available in information booths.

Variable	Definition
Graphics	'Graphics' are defined as being the pictorial accompaniment to text.
Language	'Language is defined as being either the local dialect (Cebuano or Waray Waray), The Philippines national language (Tagalog) or English.

Appendix A continued

Variable	Definition
Reading ability	'Reading ability' is defined as being 'high' in situations where farmers can read (i.e. understand words and sentence structure) texts of phrases or paragraphs. 'Low' reading ability is defined as being the ability to only read simple well-known instructions and signs only. In this situation, farmers are heavily dependent on accompanying graphics.
Comprehension	'Comprehension' is defined as the meaning which farmers place on text or graphics and is defined as being 'high' when farmers are able to decipher meaning from texts and graphics and 'low' when farmers are unable or only partly able to decipher a partial meaning from texts and graphics.
Construal	'Construal' is defined as being an interpretation or mental construction which is put on text and graphics. Construal is defined as being 'correct' or 'incorrect' depending on farmers' ability to construe the correct extension message or not.
Effectiveness as a stand-alone extension aid	'Effectiveness of a stand-alone extension aid' is defined as the percentage of farmers who both comprehend written extension materials and correctly interpret the extension message

Model 3 'Development of Farmers' Self-Efficacy'

Model 3 predicts the development of farmers' self-efficacy'—their development of self-confidence to the stage where they are confident of growing seedlings and establishing trees in the future.

Variable	Definition
General education	'General education' is defined as being either 'higher than elementary' or 'elementary of lower'. In the first category, farmers can read (i.e. understand words and sentence structure) of texts of phrases or paragraphs and can undertake simple mathematical computations, (e.g. calculate area from measurements of length and breadth). "Elementary or lower" is characterised by an inability to perform these functions.
Individual competence	'Individual competence' is aligned to level 3 of Bloom's taxonomy for psychomotor skills, the 'yes' state being achieved when farmers are able to repeat (after practice) skills which are shown to them. The 'no' state is defined as a lack of competence at level 3. The premise underpinning this use of the taxonomy is that it was developed by Bloom et al. (1956) and Bloom et al. (1971a, b) as a hierarchy of levels of learning behaviour to assist the design and assessment of learning activities. For psychomotor skills, level 3 of Bloom's taxonomy is the ability to repeat simple skills with precision, higher levels requiring integration of multiple skills. Therefore, we used level 3 as being a minimum proficiency level which may lead to the development of self-efficacy.
Theory-based learning activity	'Theory-based learning activity is defined as being the supply of underpinning theoretical information in an extension program. The 'simple' state of this variable is achieved at level 2 of Bloom's taxonomy for cognitive functions in which information is understood. The 'complex' state of this variable is achieved when the delivery of theory exceeds level 2 and requires learners to apply, analyse, synthesise or evaluate information.

Appendix A continued

Variable	Definition
Self-efficacy	In a general sense, 'self-efficacy' is defined as a personal belief about a capability to perform certain actions and exercise influence over life-affecting events (Sanna 1992, Bandura 1994). It is an important factor in determining subsequent adoption of technology (McGinty et al. 2008). In model 3, self-efficacy is defined as being 'high' when farmers are sufficiently confident about undertaking the activity that lack of knowledge or skills is not an impediment. It is defined as being 'low' when farmers are not confident about undertaking the activity.

Model 4 'Attrition of participating farmers throughout a program'

Model 4 predicts the attrition of farmers throughout a program, either because establishing trees is not feasible for them, they already have the required knowledge, they meet unexpected problems, lose interest or their trees are destroyed by natural disasters or grazing.

Variable	Definition
Initial feasibility	'Initial feasibility' is defined as being the initial practicality or possibility for farmers to establish and grow trees. It is defined as being 'feasible' or 'not feasible depending whether farmers have the land, title security, finance and time to undertake agroforestry.
Unexpected problem	'Unexpected problem' is defined as being the occurrence, either 'yes' or 'no', of an event which causes severe unexpected problems which are beyond the capacity of farmers to manage.

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